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**Kwapiszewski, Radoslaw; Jensen, Thomas Glasdam; Mogensen, Klaus Bo; Brzozka, Zbigniew ; Kutter, Jörg Peter**

*Publication date:*  
2012

*Document Version*  
Publisher's PDF, also known as Version of record

[Link back to DTU Orbit](#)

*Citation (APA):*  
Kwapiszewski, R., Jensen, T. G., Mogensen, K. B., Brzozka, Z., & Kutter, J. P. (2012). *Thiol-Ene Waveguides As Promising Components Of Optofluidic Microsystems*. Abstract from 16th International Conference of Miniaturized Systems for Chemistry and Life Sciences, Okinawa, Japan.

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## **THIOL-ENE WAVEGUIDES AS PROMISING COMPONENTS OF OPTOFLUIDIC MICROSYSTEMS**

Radoslaw Kwapiszewski\*, Thomas G. Jensen\*\*, Klaus B. Mogensen\*\*, Zbigniew Brzozka\*  
and Jörg P. Kutter\*\*

\*Department of Microbioanalytics, Faculty of Chemistry, Warsaw University of Technology,  
POLAND

\*\*Department of Micro and Nanotechnology, Technical University of Denmark, DENMARK

Fabrication of optical elements from inexpensive polymer materials using mass-production tools is a current challenge. The integration of such elements with microfluidics is a prerequisite for the successful development of various lab-on-a-chip systems and their commercialization [1].

Conventional optical fibers and waveguides are attractive due to their ability for guiding and focusing of light to measurement points, and efficient coupling to commercial light sources and detectors, thereby increasing the design flexibility [2]. However, many of the materials used for fabrication of optical waveguides (SU-8, PMMA, PC, COCs) exhibit a good transparency only in the visible range, or are costly and more challenging to work with (SU-8, glass) [3]. The efficiency and economy of the design and fabrication of optical waveguides can be considerably enhanced if ways to prepare optical elements from new types of materials are explored.

In this paper, we present thiol-ene polymers as promising materials for optofluidic applications. The thiol-ene reaction mechanism affords delayed gelation, low shrinkage, high conversion, and uniform crosslink densities resulting in the ability to obtain polymers with unique physical and mechanical properties. Moreover, thiol-ene polymers show good adhesion to other materials, good chemical resistance to organic solvents, and have high refractive index [4]. So far, thiol-ene-based polymers have been used in a number of ways to fabricate microstructures, and obtain various functional elements [5]. Here, we extend this list by using thiol-ene-based polymers as integrated planar waveguides.

1 mm wide and 500  $\mu\text{m}$  high thiol-ene waveguides were fabricated using a PDMS mould. A stoichiometric mixture of “thiol” (pentaerythritoltetrakis(3-mercaptopropionate)) and “ene” (1,3,5-triallyl-1,3,5-triazine-2,4,6(1H,3H,5H)-trione) was poured into the mould, and cured by UV exposure for 4 min. Next, the waveguides were manually inserted into the guiding microchannels of a simple PMMA system (Figs.1 and 2). After thermal bonding of a lid (85°C), the system was perfectly sealed and no leakage through the waveguide guiding channels was observed even for flow rates of 100  $\mu\text{L}/\text{min}$ . The waveguides of the microsystem could easily be connected to an external light source via optical fibers inserted into integrated coupling structures. 90-degree waveguide bends utilizing air as side-cladding enables a significantly improved transmission of the excitation light, while maintaining a small footprint of the device.

The thiol-ene waveguide microsystem connected to a LED and a PMT was validated by measurements of fluorescence from a deprotonated form of 4-methylumbelliferone ( $\lambda_{\text{ex}}=365\text{ nm}$ ,  $\lambda_{\text{em}}=445\text{ nm}$ ), which is commonly used for kinetic investigation of enzyme activity. The detection limit using the presented setup is quite low (LOD=650 nM) (Fig.3), and, comparing with the LOD of the standard method using a very sensitive spectrofluorimeter and a 1cm x 1cm quartz cuvette (10 nM), demonstrates the potential of thiol-ene-based waveguides as promising optical components. They are attractive due to their easy manipulation, fabrication, sealing within a microdevice, simple connection with optical fibers, and the further possibility of tuning different properties such as stiffness (reduced if the thiol component is used in excess) or a broader wavelength range using appropriate thiols and enes (Fig.4).

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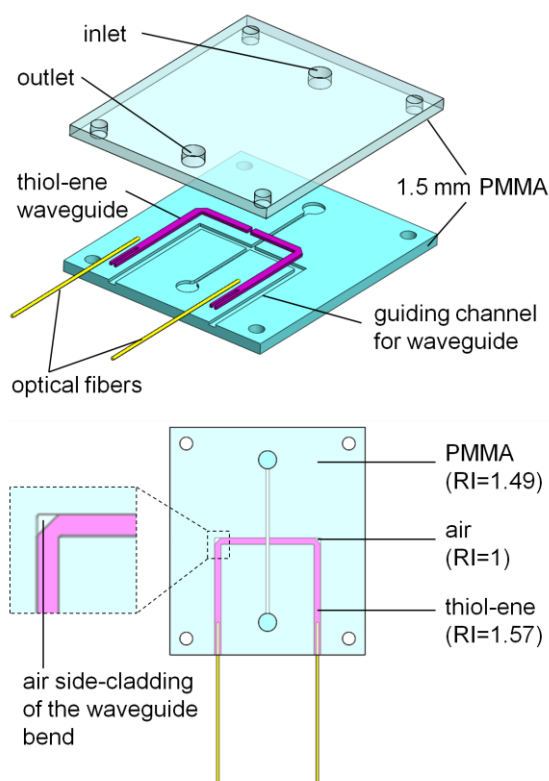


Figure 1: Schematic view of the PMMA microsystem with thiol-ene waveguides.

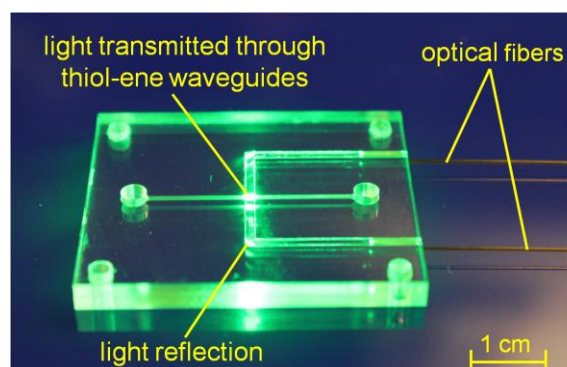


Figure 2. Photograph of the microsystem.

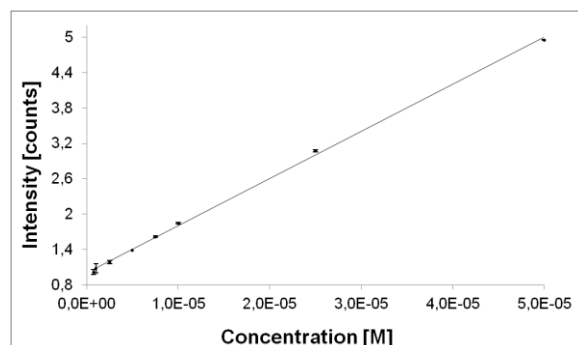


Figure 3. Calibration curve of a deprotonated form of 4-methylumbelliferone using the presented PMMA system with thiol-ene waveguides (LOD=650 nM).

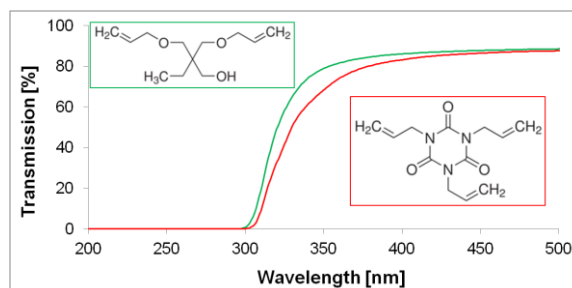


Figure 4. Optical transmission spectra of 5 mm thick blocks prepared from a stoichiometric mixture of pentaerythritoltetrakis(3-mercaptopropionate) with: trimethylolpropane diallyl ether (green curve) and 1,3,5-triallyl-1,3,5-triazine-2,4,6 (1H,3H,5H)-trione (red curve).

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